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DESCRIPTION

MACHINE STRUCTURAL STEEL PRODUCT HAVING SUPERIOR FORMABILITY OF ROLL-FORMING, QUENCHING-CRACK RESISTANCE, AND TORSIONAL PROPERTIES, AND DRIVE SHAFT

Technical Field

The present invention relates to machine structural steel products. In more particular, the present invention relates to a machine structural steel product having superior formability of rotary-forming, quenching-crack resistance, and torsional properties. A steel product is provided which is a machine structural steel product manufactured using an electric furnace instead of a blast furnace and which retains various properties even when a tramp element such as Cu or Ni is incorporated.

Background Art

Machine structural members such as drive shafts for automobile use and constant velocity joints have been requested to have a torsional strength at a required level. In order to ensure the torsional strength, heretofore, a hot-rolled steel bar has been generally processed by the steps of hot-forging, normalizing whenever necessary, cutting, cold-forging, and the like so as to have a predetermined shape, followed by induction hardening and

tempering.

In recent years, for the environment conservation, attempts have been made to reduce the weight of automobile bodies in order to improve the automobile gasoline mileage. For the reduction in weight of automobile components, it has been desired that the torsional strength of automobile members be improved. In addition, in a manufacturing process for automobile components, machinability and quenching-crack resistance of steel products have also been required.

For improving the torsional strength, it has been considered that quenched hardness and hardness penetration depth are increased by induction hardening. However, in order to increase the quenched hardness and the hardness penetration depth, either the change in high-frequency hardening conditions or the increase of the amount of alloy elements in a steel product must be carried out. In both cases described above, the manufacturing cost is inevitably increased. In order to simultaneously satisfy the torsional strength, machinability, and quenching-crack resistance of automobile components, for example, as disclosed in Patent Document 1, a technique specifying the amount of alloy elements has been proposed.

However, only by specifying chemical components according to the technique mentioned above, a problem may

arise in that the composition range is very small which simultaneously satisfies the machinability, quenching-crack resistance, and torsional properties. In addition, a problem of unstable quality has not been still solved.

Accordingly, in order to solve the problems described above, the inventors of the present invention proposed a machine structural steel product having superior machinability, quenching-crack resistance, and torsional properties as disclosed, for example, in Patent Document 2 in which the steel texture is controlled at the same time when the components of the steel product are appropriately adjusted.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 4-218641 (Claims)

Patent Document 2: Patent No. 3288563 (Claims)

However, it was found that when the machine structural steel product disclosed in Patent Document 2 is manufactured using an electric furnace, desired properties cannot be obtained, and in particular, degradation in formability of rotary-forming is significant. Compared to a steel product manufactured using a blast furnace, a tramp element such as Cu or Ni is inevitably incorporated into the steel product manufactured using an electric furnace. It is believed that the tramp elements deteriorate the formability of rotary-forming.

A primary object of the present invention is to solve the problems described above. That is, an object of the present invention is to provide a machine structural steel product which has superior quenching-crack resistance and torsional properties and which effectively prevents the degradation in formability of rotary-forming even when manufactured using an electric furnace instead of a blast furnace. In addition, a drive shaft formed from this steel product is also proposed.

Disclosure of Invention

Through long and intensive research carried out by the inventors of the present invention in order to achieve the above objects, the following findings were obtained.

(1) In order to suppress the adverse influences of tramp elements, it is effective to increase the amount of Cr;

(2) however, the increase of the amount of Cr causes the degradation in formability of rotary-forming, and also causes the degradation in torsional properties and machinability;

(3) the degradation in torsional properties and machinability concomitant with the increase of the amount of Cr can be solved by increase of the amount of Si and, in addition, by decrease of the amount of Mn; and

(4) the degradation in formability of rotary-forming can be

overcome when an LD value, which is an index of the texture and the hardness through the hardenability, is controlled in a predetermined range.

The present invention was made on the above findings, and the particular aspects of the present invention are as follows.

1. A machine structural steel product provided with superior formability of rotary-forming, quenching-crack resistance, and torsional properties, which comprises: on a mass percent basis,

C: 0.35% to 0.50%;

Si: 0.15% or less;

Mn: 0.20% to 1.1%;

P: 0.02% or less;

S: 0.005% to 0.035%;

Cr: more than 0.1% to 0.2%;

Mo: 0.05% to 0.5%;

Ti: 0.01% to 0.05%;

Al: 0.01% to 0.05%;

N: 0.01% or less;

B: 0.0005% to 0.0050%;

Cu: 0.06% to 0.25%; and

Ni: 0.05% to 0.2%,

wherein an LD value represented by the following equation (1) of 120 or less is satisfied, and the balance of the

composition includes Fe and inevitable impurities.

Note

$$LD=0.569\times\{7.98\times(C)\}^{1/2}\times(1+4.1Mn)\cdot(1+2.83P)\cdot(1-0.62S)\cdot(1+0.64Si)\cdot(1+2.33Cr)\cdot(1+0.52Ni)\cdot(1+3.14Mo)\cdot(1+0.27Cu)\cdot(1+1.5(0.9-C))\}+52.6 \quad \cdots\cdots (1)$$

In the above equation, C, Mn, P, S, Si, Cr, Ni, Mo, and Cu in the equation each indicate the content (mass percent) of the respective elements.

2. The machine structural steel product having superior formability of rotary-forming, quenching-crack resistance, and torsional properties, according to the above 1, which further comprises: on a mass percent basis,

V: 0.01% to 0.30%, and

Nb; 0.005% to 0.05%.

3. A drive shaft comprising the machine structural steel product according to the above 1 or 2, wherein a hardened layer is provided by performing induction hardening and tempering.

Brief Description of the Drawings

Fig. 1 is a graph showing the influence of an LD value on the formability of rotary-forming.

Fig. 2 shows the results of measurement of the static

strength of a drive shaft measured by a static strength test.

Fig. 3 shows the results of measurement of the fatigue strength of a drive shaft of an example and that of a comparative example.

Best Mode for Carrying Out the Invention

Hereinafter, the present invention will be described in detail. The reasons the composition of a steel product of the present invention is specified in the above range will be described. In the present invention, "%" used for components indicates "mass percent", unless otherwise stated.

C: 0.35% or more, 0.50% or less

C is an element having the largest influence on the high-frequency hardenability and is an effective element for increasing the hardness and the depth of a hardened layer by quenching and for ensuring a torsional strength of 1,400 MPa or more after induction hardening and tempering. However, when the content is less than 0.35%, the effect of the carbon component is not sufficient, and when the content is more than 0.50%, the machinability and quenching-crack resistance are degraded. Accordingly, the C content is set in the range of from 0.35% to 0.50%.

Si: 0.15% or less

In addition to a function as a deoxidizing element, Si is an element having a function of reinforcing steel when

being dissolved in ferrite, thereby improving the torsional strength. The content is preferably more than 0.05%. However, when the Si content is more than 0.15%, the machinability is remarkably deteriorated, and hence the content is set to 0.15% or less.

Mn: 0.2% or more, 1.1% or less

Mn is an effective element for improving the hardenability and increasing the hardness penetration depth in induction hardening, thereby contributing the improvement of the torsional strength. However, when the content is less than 0.2%, the effect of the Mn component is not sufficient. On the other hand, when the content is more than 1.1%, in addition to the formability of rotary-forming, the machinability and the torsional strength are also degraded. Accordingly, the content of Mn is set in the range of from 0.2% to 1.1%. Preferable content is in the range of from 0.2% to 0.8%.

P: 0.020% or less

Since P is liable to segregate in austenite grain boundaries in quenching and to facilitate quenching-cracking, the content of P is preferably decreased as small as possible. From this point of view, the content is decreased to 0.020% or less.

S: 0.005% or more, 0.035% or less

S forms MnS in steel and has a function of improving

the machinability, and hence the content is set to 0.005% or more. However, since MnS tends to initiate cracking and causes the decrease in strength and toughness, the maximum content of S is set to 0.035%. Preferable content is in the range of from 0.010% to 0.035%.

Cr: more than 0.1%, 0.2% or less

Cr is a particularly important element in the present invention, and when Cr is contained, the adverse influence of tramp elements such as Cu and Ni can be advantageously removed, the adverse influence being degradation in formability of rotary-forming, torsion properties, machinability, and the like. However, when the content of Cr is 0.1% or less, the effect of Cr component is not sufficient. On the other hand, when the content is more than 0.2%, since the formability of rotary-forming, machinability, and torsional strength are degraded, the content of Cr is set to more than 0.1% to 0.2%.

Mo: 0.05% or more, 0.5% or less

Mo is not only effective for improving the hardenability but also has a function of facilitating the growth of bainite so as to improve the machinability. Hence, the content must be 0.05% or more; however, when the content is more than 0.5%, the machinability is adversely degraded. Accordingly, the content of Mo is set in the range of from 0.05% to 0.5%. Preferable content is in the range of from

0.1% to 0.5%.

Ti: 0.01% or more, 0.05% or less

Ti forms a nitride with N and reduces the grain size of austenite in high-temperature heating. This element is essential for ensuring dissolved B that is effective for improving the hardenability. Hence, the content must be 0.01% or more; however, when the content is more than 0.05%, the toughness is degraded. Accordingly, the content of Ti is set in the range of from 0.01% to 0.05%.

Al: 0.01% or more, 0.05% or less

Al is an effective element as a deoxidizing agent, and to obtain this effect, the content thereof must be at least 0.01%. However, when the content is more than 0.05%, giant alumina grains are grown and initiates fatigue damage, thereby decreasing the fatigue strength. Hence, the content of Ai is set in the range of from 0.01% to 0.05%.

N: 0.01% or less

N is an effective element for forming a nitride with Al or Ti and for reducing the grain size of austenite in high-frequency heating, and hence the fatigue strength can be improved. However, when the content thereof is more than 0.01%, the nitride is coarsely grown, and the fatigue strength is adversely degraded. In addition, when an excessive amount of N is contained, BN is formed, and as a result, the amount of dissolved B component effective for

improving the hardenability is disadvantageously decreased. Hence, the content of N is set to 0.01% or less.

B: 0.0005% or more, 0.0050% or less

B has an effect of improving the torsional strength by improving the hardenability and by increasing the hardness penetration depth in high-frequency hardening. In order to obtain the above effect, the content thereof must be 0.0005% or more; however, when the content is more than 0.0050%, the toughness is decreased. Hence, the content of B is set in the range of from 0.0005% to 0.0050%.

Cu: 0.06% or more, 0.25% or less

Cu is an element which is inevitably incorporated as a tramp element. When the content is more than 0.25%, degradation in formability of rotary-forming and the like may occur in some cases, and hence the content is set to 0.25% or less. On the other hand, when the content is decreased to less than 0.06%, the manufacturing cost is increased, and as a result, the content is set to 0.06% or more.

Ni: 0.05% or more, 0.2% or less

Ni is an element which is inevitably incorporated as a tramp element. When the content is more than 0.2%, degradation in formability of rotary-forming and the like may occur in some cases, and hence the content is set to 0.2% or less. On the other hand, when the content is

decreased to less than 0.05%, the manufacturing cost is increased, and as a result, the content is set to 0.05% or more.

The primary components are described above, and according to the present invention, in addition to those components, the following elements may also be optionally used.

V: 0.01% or more, 0.30% or less, and Nb: 0.005% or more, 0.050% or less

Both V and Nb form carbonitrides and reduce the grain size of austenite, thereby effectively contributing the improvement of strength. However, when the contents of V and Nb are less than 0.01% and less than 0.005%, respectively, the effects thereof are not sufficient. On the other hand, when the contents of V and Nb are more than 0.30% and more than 0.050%, respectively, a large and coarse material is precipitated, and the toughness is decreased thereby. Hence, the content of V is set in the range of from 0.01% to 0.30%, and the content of Nb is set in the range of from 0.005% to 0.050%.

Although the appropriate ranges of the components are described above, according to the present invention, it is not enough that the individual components simply satisfy the above ranges, and the individual components must be controlled so that the LD value represented by the following

equation (1) is 120 or less.

Note

$$LD=0.569\times\{7.98\times(C)\}^{1/2}\times(1+4.1Mn)\cdot(1+2.83P)\cdot(1-0.62S)\cdot(1+0.64Si)\cdot(1+2.33Cr)\cdot(1+0.52Ni)\cdot(1+3.14Mo)\cdot(1+0.27Cu)\cdot(1+1.5(0.9-C))\}+52.6 \quad \cdots\cdots (1)$$

In the above equation, C, Mn, P, S, Si, Cr, Ni, Mo, and Cu each indicate the content (mass percent) of the respective elements.

This LD value is the index of the texture and the hardness through the hardenability.

Fig. 1 shows the results of measurement of the influence of the LD value on the formability of rotary-forming of high Cr steel and high Si steel. In addition, in the figure described above, the results of measurement of low Cr and low Si steel disclosed in Patent Document 2 described above are also shown for comparison.

In this embodiment, the formability of rotary-forming are evaluated by a die life obtained in a form-rolling test.

As shown in the figure, in both cases, when the LD value is more than 120, the die life is rapidly decreased; however, when the LD value is 120 or less, the die life, that is, the formability of rotary-forming, of the high Cr and high Si steel of the present invention is much superior.

Accordingly, in the present invention, the components

are controlled to obtain an LD value of 120 or less.

In the present invention, the steel texture is not particularly specified; however, a texture composed of ferrite as a primary component and approximately 5 to 30% of a bainite phase on an area percent basis is preferably used.

The steel product described above is most preferably used for power transmission devices, particularly for automobile drive shafts and constant velocity joints. In addition to the superior machinability, since the load carrying capacity is increased, a significant advantage, that is, weight reduction, can be obtained.

Next, preferable manufacturing conditions according to the present invention will be described.

A steel melting method for the steel product of the present invention may be performed by a known method and is not particularly limited. The machine structural steel of the present invention has superior formability of rotary-forming even when Cu or Ni is incorporated, which is difficult to be removed in steel melting performed by using an electric furnace, and hence the steel melting is preferably performed using an electric furnace. Vacuum degassing such as RH degassing, refining using ladles, and the like may be additionally performed. Molten steel is solidified by a continuous casting method or an ingot-making method and is then formed into materials having

predetermined shapes through hot rolling or hot/warm forging. After processed by intermediate heat treatment, whenever necessary, such as normalizing, spheroidized annealing, or softening annealing, the materials thus obtained are finished into a desired shape by cold working such as cutting, forging, or form rolling.

In the present invention, the product having a predetermined shape is formed by hot rolling or hot forging, or is then further processed by normalizing. Cooling after the formation of austenite by this hot rolling or hot forging followed by normalizing or the like is preferably performed at a rate of approximately 0.2 to 2.0°C/sec in order to produce an appropriate amount of bainite. In particular, for a steel bar having a large diameter, accelerated cooling in which cooling is controlled is preferably performed.

In addition, final induction hardening and tempering may be performed by heating for approximately 0.2 to 1.0 second at an output of approximately 120 kW using a induction hardening apparatus at a frequency of approximately 15 kHz, followed by tempering at a temperature of 170°C for approximately 30 minutes.

Examples

Steel having the composition shown in Table 1 was melted in a steel converter, followed by continuous casting

to form a bloom having a size of 400 × 540 mm, and subsequently, a billet of 150 mm square was formed therefrom by hot rolling. Next, this billet was formed into a straight bar 25 mm in diameter by heating to 1,030°C, followed by hot rolling, and was then air-cooled at a cooling rate of 0.7°C/sec.

The results of measurement of the texture, formability of rotary-forming, torsional properties, and quenching-crack resistance of the bar steel thus formed are shown in Table 2.

The measurement method of the steel texture and the various properties are as follows.

(1) Texture

After a photograph of the mictrotexture of the straight bar after cooling was taken using an optical microscope, the texture of the steel was identified from this photograph, and in addition, the area percent of a bainite phase was measured by an image analyzer.

(2) Formability of rotary-forming

The formability of rotary-forming were evaluated by the die life in accordance with a form-rolling test. The die life was determined by the number of material which was form-rolled until the form-rolling could not be further continued due to tooth tipping, peeling of a fracture surface, tooth abrasion, and the like.

The material of the die was SKD 11, and the spline data

were as follows.

Tooth form: involute form, module: 1.27, pressure angle: 30°, number of teeth: 21, pitch diameter: 26.27 mm, large diameter: 28.1 mm, small diameter: 24.88 mm, over-pin diameter (pin 2.5 mm in diameter): 30.49 mm

(3) Torsional Properties

After a torsion test piece in the form of a smooth round bar having a parallel portion 20 mm in diameter was formed from a straight bar and was then quenched at a frequency of 15 kHz using a induction hardening apparatus, tempering treatment at 170°C for 30 minutes was performed, and the torsion test was then performed. The hardness penetration depth after the induction hardening and tempering was set to approximately 4 mm. The torsion test was performed by using a torsion tester of 4,900 J (500 kgf·m), and the maximum torsional shear strength was measured as the torsional strength.

(4) Quenching-crack Resistance

For the measurement of the quenching-crack resistance, a round bar (20 mm in diameter) having a V-shaped groove on the surface thereof along the shaft direction was formed from the above straight bar 25 mm in diameter and was then processed by induction hardening equivalent to that described above. After 10 locations on a C cross-section of the round bar were polished and observed, the evaluation was

performed by the number of generated cracks.

(5) Machinability

For the test of the machinability, an opening having a length of 12 mm was formed using a drill made of SKH 4 having a diameter of 4 mm at a rotation speed of 1,500 rpm, and the operation described above was repeated until the formation of the opening could not be further continued, thereby obtaining the total length (mm) of the openings. This total length of the openings thus formed was evaluated as a tool life.

As can be apparently seen from Table 2, the steel products obtained according to the present invention have superior formability of rotary-forming, torsional properties, quenching-crack resistance, and machinability.

The static strength and the fatigue strength of a drive shaft, which was formed from the steel product of the present invention provided with a hardened layer by induction hardening and tempering, will be described with reference to Figs. 2 and 3, respectively. The drive shaft of the example according to the present invention was formed from a steel product of No. 2 shown in Table 1. The drive shaft of the comparative example was formed from a steel product of No. 18 shown in Table 1. Fig. 2 is a graph

showing the results of measurement of the static strength of the drive shafts by a static strength test. The static strength test (static strength test) is to evaluate the static strength by measuring the maximum torque obtained when the drive shaft is broken. The number of the drive shafts used for the test was one for the comparative example and two for the examples. The results of the comparative example, example 1, and example 2 are shown in Fig. 2. The maximum torque obtained when the drive shaft of the comparative example was broken is set to be 1, and the maximum torque obtained when the drive shaft of the example was broken was represented by the ratio thereto. It was understood that the static strength of the drive shaft of the example was improved by approximately 1.17 times that of the drive shaft of the comparative example.

Fig. 3 is a graph showing the results of the fatigue strengths of the drive shaft of the example and the drive shaft of the comparative example measured by a fatigue strength test. The fatigue strength test is a test for measuring the fatigue strength obtained when torque is repeatedly loaded. A predetermined load torque is repeatedly applied to the drive shaft, and the number of cycles N of load application which causes the fracture of the drive shaft is obtained. The vertical axis indicates the value obtained by dividing the load torque by the static

strength of the drive shaft of the comparative example, and the value thus obtained is dimensionless. The horizontal axis indicates the number of cycles of load application causing the fracture of the drive shaft. From the test results thus obtained, for example, when the number of cycles was 10,000, the value along the vertical axis of drive shaft of the comparative example was approximately 0.49, and on the other hand, the value along the vertical axis of the drive shaft of the example was approximately 0.55. Hence, it was understood that the fatigue strength of the drive shaft of the example was improved by approximately 10% as compared to that of the comparative example.

Industrial Applicability

According to the present invention, adverse influences of tramp element can be removed even from a machine structural steel product manufactured by using an electric furnace, the tramp elements being inevitably incorporated in the steel product. A steel product can be obtained having superior formability of rotary-forming, torsional properties, quenching-crack resistance, and hardenability. In particular, when the steel product according to the present invention is used for forming power transmission devices, such as automobile drive shafts and velocity constant joints, in addition to superior machinability, significant advantage,

that is, weight reduction, can be obtained due to the high strength.

Table 1

No.	Composition (mass %)															LD value
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al	Ti	B	N	V	Nb	
1	0.37	0.05	0.83	0.015	0.030	0.08	0.05	0.08	0.19	0.028	0.030	0.0032	0.0051	-	-	98.4
2	0.40	0.08	0.45	0.013	0.018	0.16	0.16	0.16	0.17	0.032	0.019	0.0022	0.0044	-	-	89.3
3	0.39	0.08	0.25	0.011	0.020	0.16	0.15	0.15	0.16	0.040	0.020	0.0020	0.0038	-	-	77.3
4	0.47	0.06	0.56	0.009	0.022	0.12	0.10	0.09	0.17	0.015	0.024	0.0017	0.0076	-	-	88.3
5	0.42	0.10	0.65	0.013	0.020	0.11	0.10	0.11	0.25	0.025	0.015	0.0023	0.0041	0.11	-	101.7
6	0.40	0.08	0.95	0.016	0.015	0.16	0.16	0.16	0.12	0.023	0.024	0.0022	0.0045	-	0.020	109.8
7	0.41	0.06	0.70	0.019	0.006	0.11	0.12	0.12	0.36	0.026	0.019	0.0019	0.0048	-	-	116.1
8	0.40	0.08	0.60	0.019	0.007	0.16	0.16	0.17	0.35	0.026	0.025	0.0020	0.0052	-	-	116.1
9	0.40	0.04	0.88	0.019	0.006	0.06	0.06	0.06	0.35	0.022	0.020	0.0025	0.0044	-	-	116.4
10	0.41	0.07	0.60	0.016	0.015	0.11	0.10	0.12	0.15	0.023	0.024	0.0022	0.0045	0.15	0.032	91.1
11	0.40	0.06	0.84	0.018	0.007	0.11	0.11	0.11	0.35	0.025	0.023	0.0020	0.0041	-	-	122.2
12	0.41	0.08	0.73	0.019	0.007	0.16	0.16	0.15	0.34	0.023	0.024	0.0023	0.0047	-	-	122.6
13	0.42	0.04	0.99	0.018	0.006	0.06	0.06	0.06	0.35	0.024	0.021	0.0018	0.0045	-	-	121.5
14	0.61	0.06	0.63	0.012	0.021	0.13	0.12	0.13	0.16	0.022	0.019	0.0019	0.0054	-	-	94.2
15	0.31	0.08	0.57	0.011	0.020	0.15	0.16	0.13	0.17	0.031	0.020	0.0018	0.0060	-	-	90.9
16	0.40	0.04	1.22	0.014	0.023	0.16	0.15	0.17	0.26	0.034	0.017	0.0018	0.0065	-	-	143.0
17	0.42	0.23	0.70	0.025	0.024	0.14	0.11	0.10	0.16	0.025	0.024	0.0016	0.0056	-	-	100.8
18	0.39	0.04	0.54	0.014	0.045	0.25	0.26	0.26	0.15	0.022	0.023	0.0022	0.0048	-	-	100.3
19	0.40	0.05	0.48	0.014	0.020	0.11	0.10	0.11	0.62	0.024	0.020	0.0025	0.0046	-	-	116.0
20	0.38	0.05	0.52	0.013	0.018	0.11	0.11	0.09	0.03	0.025	0.022	0.0017	0.0049	-	-	76.4
21	0.37	0.02	1.00	0.015	0.030	0.08	0.05	0.03	0.35	0.021	0.023	0.0032	0.0052	-	-	114.3

Table 2

No.	Texture*	Bainite ratio (%)	Die life (Number of pieces)	Torsional strength (MPa)	Number of quenching-crack (Number of pieces)	Tool life (mm)	Remarks
1	F + P + B	12	610	1540	15	2430	Example
2	F + P + B	14	624	1580	16	2480	Example
3	F + P + B	10	642	1570	10	2300	Example
4	F + P + B	13	588	1630	19	2390	Example
5	F + P + B	18	591	1590	18	1740	Example
6	F + P + B	8	525	1570	18	2110	Example
7	F + P + B	23	493	1580	19	2470	Example
8	F + P + B	21	469	1590	19	2450	Example
9	F + P + B	20	512	1580	20	2440	Example
10	F + P + B	10	658	1620	16	2120	Example
11	F + P + B	21	253	1590	18	2300	Comparative example
12	F + P + B	19	218	1580	19	2320	Comparative example
13	F + P + B	22	226	1600	21	2310	Comparative example
14	F + P + B	11	599	1650	45	1120	Comparative example
15	F + P + B	7	635	1190	4	2130	Comparative example
16	F + P + B	14	151	1430	19	1940	Comparative example
17	F + P + B	17	585	1560	24	1290	Comparative example
18	F + P + B	16	523	1400	17	1270	Comparative example
19	F + P + B	45	514	1600	16	1510	Comparative example
20	F + P	0	663	1550	11	1330	Comparative example
21	F + P + B	26	360	1530	17	2400	Comparative example

* F: Ferrite, P: Perlite, B: Bainite